INSTRUCTION MANUAL

TYPE --

MV-928A

RF Millivoltmeter

MILLIVAC INSTRUMENTS

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INSTRUCTION MANUAL

MV-928A

RF Millivoltmeter

INSTRUMENT SHOP

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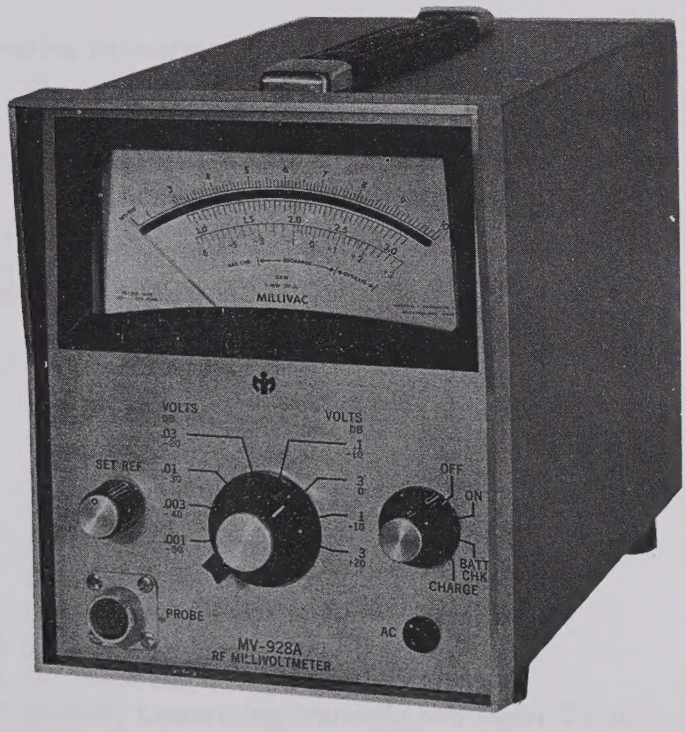

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SPECIFICATIONS

FREQUENCY RESPONSE & ACCURACY.....

3mV to 3V FS ranges		1mV FS range only	
10KHz to 100MHz	± 3%	10KHz to 100MHz	± 5%
100MHz to 400MHz	± 5%	100MHz to 400MHz	± 10%
400MHz to 1.2GHz	±10%	400MHz to 1.2GHz	± 15%

(see frequency response curve on next page)

SCALE DISTRIBUTION..... Expanded linear scale on all ranges

VOLTAGE RANGES..... 8, 1mV to 3V full scale

RESOLUTION..... 10μV (above 300μV)

SENSITIVITY..... 1mV FS, Lowest readability 100μV

DB SCALE..... 11db per range with 10db between ranges 0-dbm is equivalent to 1MW into 50Ω

INPUT IMPEDANCE (Typical Values)..... Approx. 2.2pF and 200K ohm; both components are a function of RF frequency and level (see Fig. 1-2 on Page 3)

RESPONSE..... True RMS up to 30mV; peak above 30mV, (calibrated in equivalent terms of RMS sine wave); true RMS up to 3V with 100:1 divider

CREST FACTOR..... 450 to 1.4 (function of input voltage)

AMPLIFIER OUTPUT (across 2K)..... 1.0V DC, 500μA @ full scale

ACCESSORIES FURNISHED..... Probe with cable, high impedance tip, BNC 50Ω termination adapter and output plug

OTHER ACCESSORIES AVAILABLE..... 100:1 capacitive voltage divider; BNC, infinite impedance adapter, and Type N "Tee" bridging adapter

POWER..... Approx. 12 watts @ 115/230V AC, 50-450Hz

BATTERY OPERATION..... Minimum 8-hours after overnight recharging

INDICATING METER..... 6" taut-band movement with mirror-scale dial

DIMENSIONS..... Cabinet.....9"H, 6-1/2"W, 11-1/4"D
Rackmount.....5-1/4"H, 19"W, 13"D

WEIGHT..... Cabinet or Rackmount....11 lbs. (net), 13 lbs. (shipping)

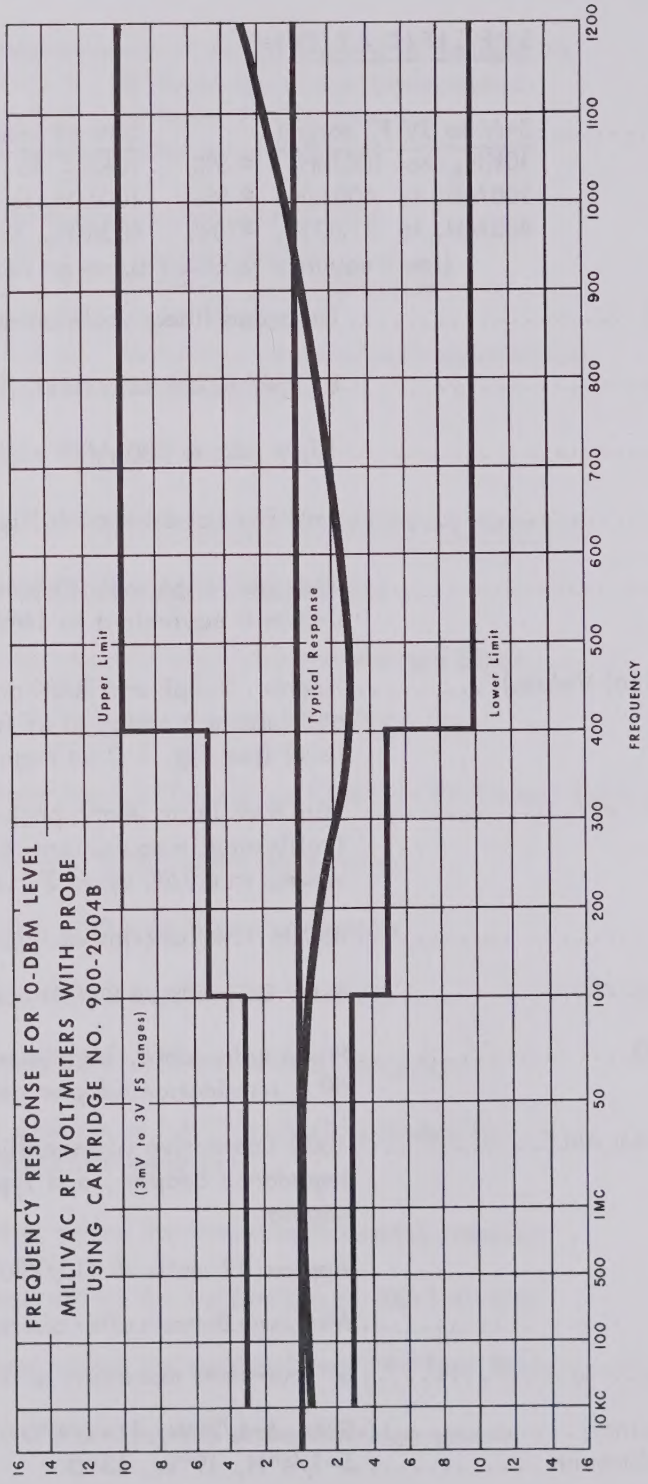

FREQUENCY RESPONSE FOR 0-DBM LEVEL
MILLIVAC RF VOLTMETERS WITH PROBE
USING CARTRIDGE NO. 900-2004B
(3mV to 3V FS ranges)
Upper Limit
Typical Response
Lower Limit
PERCENT
FREQUENCY
16
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
10 KC
100
500
1 MC
50
100
200
300
400
500
600
700
800
900
1000
1100
1200

FIG. 1-1

SECTION 1

GENERAL DESCRIPTION

1-1 FUNCTION OF THE INSTRUMENT

The MV-928A, RF Millivoltmeter offers a high order of stability through its entire range, from 100μV to 3V (300V with 100:1 capacitive divider). Solid-state circuitry, combined with a DC driven 94Hz electro-mechanical chopper, insures very low-noise performance. For battery operation, a built-in and re-chargeable ni-cad battery is furnished providing a minimum of 8-hours continuous operation after an overnight charge. Remove line cord from AC source during battery operation.

1-2 INSTRUMENT FEATURES

A. No warm-up time or heat rise due to solid-state circuitry

B. Battery operation or line operation. Operates at either 115V or 230V; 50 to 450Hz (See Sect. 2-1, 1st Para.)

C. Temperature-compensated probe with a replaceable Diode Cartridge

D. 6" linear expanded, miror-scale meter movement with taut-band suspension

E. 10KHz - 1.2GHz frequency response with usable indication to beyond 4.0GHz

F. Lightweight and compact, weighing approximately 11 lbs. with battery
Size: 9"H x 6-1/2"W x 11-1/4"D, overall

1-3 ELECTRICAL CHARACTERISTICS

The MV-928A probe employs two special, low-capacity, high stability germanium diodes in a full-wave configuration for RF detection. The measuring capability of the instrument is from 100μV to 3V in 8 ranges. It covers RF voltages reaching from the square-law region, (100μV to 30mV) to the region of linear rectification (1V to 3V). In the square-law region the instrument is RMS responding, while in the linear region it is peak-responding. In the 30mV to 1V "transition" region, the diode characteristics gradually change from RMS to peak. This non-linear characteristic is true of all diode rectifiers regardless of design and manufacture. Fortunately, in most applications, because of flywheel effect and harmonic filtering of tank circuits, the RF signals, at least at the oscillator circuit, will be found to be essentially sinusoidal. The instrument is calibrated in terms of RMS on all 8 ranges. However, it must be realized that some error will be introduced if the RF waveshape is other than sinusoidal above the 30mV level. If RMS measurements of non-sinusoidal signals are desired at levels in excess of 30mV, the use of the Millivac 100:1 capacitive divider is recommended. For example, this device will divide a 3V RF signal to 30mV, allowing the probe's diodes to operate in the RMS region. There are, however, some measurements, such as two-tone test set-ups for the adjustment and measurement of linear RF amplifiers in SSB service that require the use of an RMS calibrated, peak-reading RF voltmeter. Therefore, only for certain applications, depending upon the RF level involved, it may be advantageous to use the capacitive divider.

Semi-conductor diodes have several other characteristics that the user of the instrument should be aware of:

A. The capacity of the diodes varies inversely with signal level. Probe input capacity varies from approximately 1pF at 3V to 2.7pF at 10mV. (See Fig. 1-2 below).

B. The shunt resistance of the diodes varies inversely with both signal level and frequency. For details, refer to Fig. 1-4 on Page 3.

C. The shunt resistance and capacity of the 100:1 divider is also a function of both frequency and level.

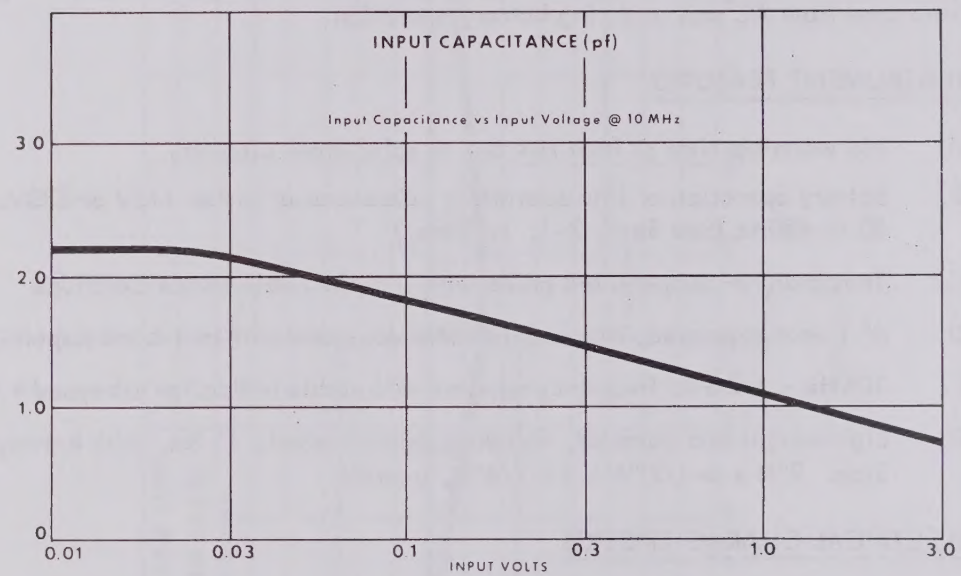


FIG 1-2

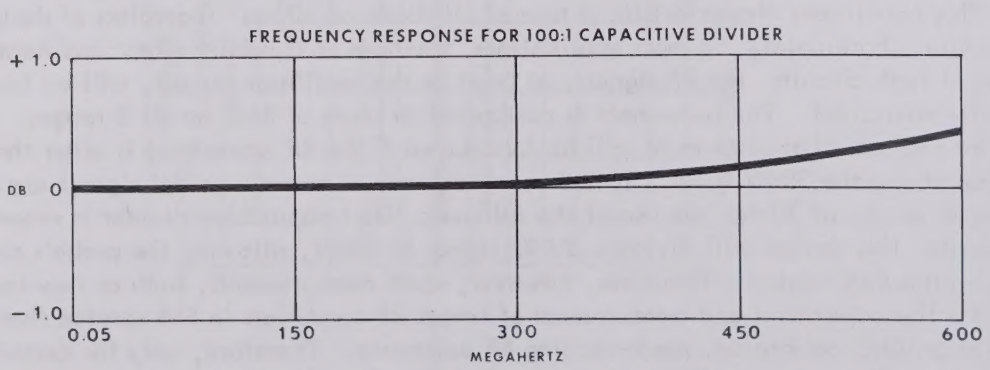


FIG. 1-3

INPUT IMPEDANCE

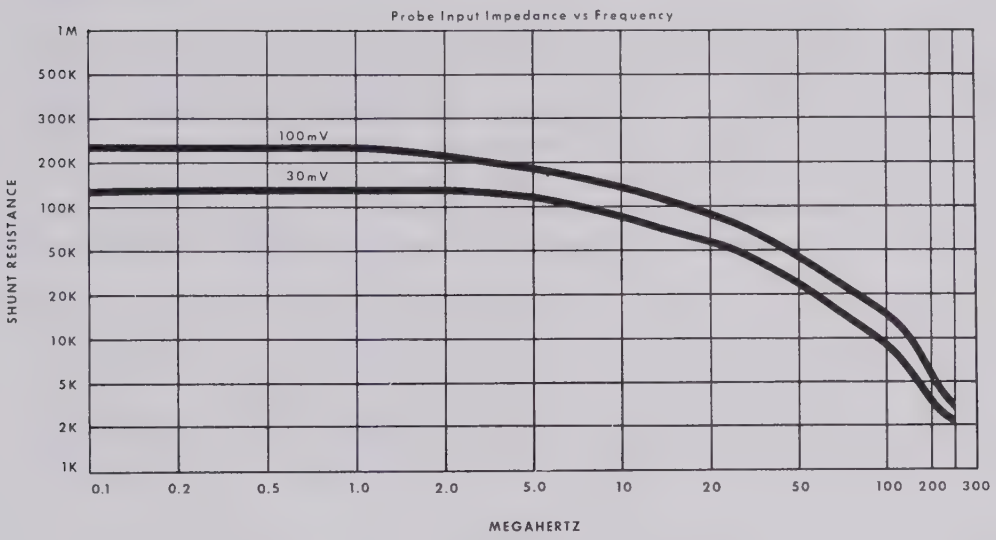


FIG 1-4

VSWR

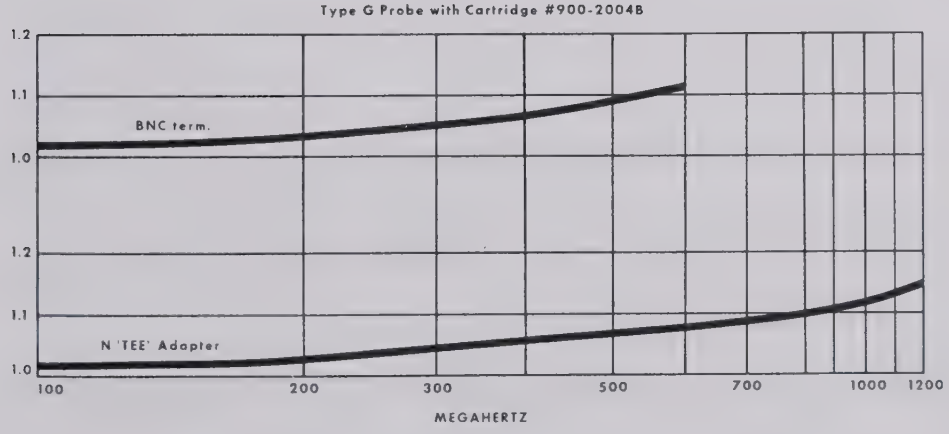


FIG 1-5

SECTION 2

OPERATING INSTRUCTIONS

2-1 OPERATION

After unpacking the instrument and probe, make sure no concealed damage has been incurred during transit. Check that the LINE VOLTAGE slide switch on the rear of the instrument agrees with the local line voltage. If necessary, it can be changed with the aid of a screwdriver. Insert the 3-wire power cable into the polarized power socket, located at the rear of the instrument. The instrument will operate on power line frequencies from 50-450Hz. Unless otherwise specified the input hum rejection filter is adjusted for 60Hz operation. For operation at another power line frequency, the input filter must be re-tuned.

Connect the type G-RF probe to the instrument, lining up the key - way in the probe socket with its mating plug. A clock-wise rotation of the plug's collar will lock the connector assembly together. The instrument is energized by turning the power switch to ON. If the instrument is operated without the probe connected to it and unless the range switch is set at the 3V position, the instrument's indicating meter may drift off scale. Allowing the indicator to drift off scale, however, will not harm the instrument in any way.

Having attached the appropriate probe accessory (BNC termination, high impedance tip, etc), select the desired range for measurement, or if the voltage to be measured is unknown, start with the highest range (3V) and work down until a reading is obtained. The SET REF control should be used to adjust the meter pointer to the SET REF mark under zero-input signal conditions. This should be done preferably on the lowest range of the instrument, with the input to the probe either terminated or shorted. No re-adjustment should be necessary when switching the instrument to its higher ranges.

At the low end of the 1mV scale, 100μV and 200μV points are provided. These are designated by the small numerals 1 and 2 and should be used only on this range.

2-2 GENERAL PRECAUTIONS

There are certain precautions that should be observed, in addition to those already mentioned in the preceeding paragraphs.

A. Maximum Allowable Overload. Damage to the diode cartridge may result if the following input limits are exceeded:

RF - 25V, P-P DC - 500V

For RF voltages in excess of 3V, our 100:1 capacitive divider is required. (Sec. 2-4A)

Millivac's warranty does not apply to burned-out diode cartridges

B. Overload Recovery. Should any of the ranges, especially the lower ranges be overloaded, it is advisable to turn the range switch to the 3V position to facilitate a faster overload recover. This will in effect discharge the input filter capacitors through the Resistor R408.

C. Power Dissipation Rating. All Millivac terminations for the Type G probe, with the exception of the infinite impedance adapter, are designed for 5 watt dissipation.

Do not exceed 5 watts RF when using any of the terminated adapters.

D. Mis-Termination. High frequency signal generators have terminated output transmission lines. The terminating resistance, corresponding to the characteristic impedance of the transmission line, is usually installed between the output terminals at the free end of the transmission line. Some generators may have the transmission line terminated in its characteristic impedance internally at the output connector. In this case, if the external transmission line is also terminated in 50Ω serious measuring errors may result. To avoid this mis-match, the user must check the generator in question to determine if the line is internally terminated. If such is the case, the resistor should be disconnected, allowing the 50Ω termination of the instrument's probe to become the required output matching resistance. If it is not desirable to remove the internal terminating resistor, an infinite impedance adapter should be used. The adapter is available from Millivac as an extra accessory.

E. Measurements by means of the High Impedance Probe Tip. (Sec. 2-3C). When making high impedance measurements by means of the high-impedance probe tip, care must be exercised in measuring low levels because of the possibility of stray RF pick-up. The lowest level at which the probe is useful will depend upon the strength of the stray RF field. Due to the fact that the probe is a very wide-band device (10KHz - 4.0GHz), any RF signal present within the probe's response (AM-FM-TV broadcasting, point-to-point communication, etc) may be detected. In addition, above 100MHz, the inductance of the tip and ground lead, plus the probe's shunt capacitance, may cause resonances, creating large measuring errors. However, the probe is still useful for relative readings. Because of its shunt capacitance and resistance, the effective impedance drops appreciably above 100MHz.

2-3 ACCESSORIES FURNISHED

A. Type G Probe. This instrument employs a probe with a replaceable diode cartridge. The cartridge contains the input coupling and output filter capacitors. Its spring-loaded construction guarantees positive contact with the various threaded accessories.

The built-in, temperature-compensating network is epoxy encapsulated and the entire probe and cable assembly is sealed, with the exception of the replaceable diode cartridge assembly. The probe should provide years of dependable service, the diode cartridge being the only part subject to electrical damage and easily replaceable. If the probe, other than the cartridge, ever needs service, it is recommended that it be returned to Millivac for replacement or repair.

B. Type BNC Termination Adapter (50Ω normally supplied with the instrument). This is the most widely used termination with a VSWR of less than 1.2:1 to 600MHz. It is not recommended for accurate measurements above this frequency. The termination has a 5 watt power rating. Refer to Section 2-2, General Precautions, when using the BNC termination.

C. High-Impedance Probe Tip. This tip, furnished with the meter, allows high impedance measurements up to 100MHz. Refer to Section 2-2, General Precautions, when using the high-impedance probe tip.

D. Output Plug. The output plug furnished with the meter is the ring, tip, sleeve type. Referring to the schematic, it will be noted that the output jack is connected across a 2K precision resistor in series with the meter movement to ground. When the plug is inserted into the jack, this resistor is removed from the circuit. The external load then used must make up for this resistance. If replaced by a recorder or other external device with low resistance, it may be necessary to adjust the resistance to make a total of 2K. The accuracy of the instrument depends upon this 2K resistance and it is recommended that it be held within ±1%. If the recorder is of the high-impedance type (500K or higher) a 2K ±1% resistor may be placed across the tip and ring of the plug and connected directly to the recorder. The output voltage is proportionate to the scale reading and full scale deflection equals 1.0V DC. The output voltage is positive with respect to chassis ground. The positive signal appears at the tip, with the ring being ground return.

2-4 ADDITIONAL ACCESSORIES AVAILABLE

A. 100:1 Capacitive Divider. When used between the probe and high-impedance tip or termination, the capacitive divider permits measurements up to 300V. It may also be used to attenuate RF levels from 30mV to 300μV, and from 3V to 30mV, making the instrument True RMS reading at these levels. The capacitive divider has an input capacitance of approximately 2pF and an input resistance of approximately 100 megohms. Its frequency response is flat from 10KHz to 600MHz. The capacitive divider is useful but not calibrated to 1.2GHz, exhibiting a slight rising characteristic caused by internal resonance. These values, however, are also functions of both level and frequency. (See Fig. 1-3).

B. Infinite Impedance BNC. The infinite impedance adapter is available where no termination is required and where it is important that the input to the probe is properly shielded.

C. Bridging N Tee Adapter (50Ω). This adapter, when used in conjunction with the G probe for in-line RF measurements, provides low VSWR at high frequencies (better than 1.2:1 at 1.2GHz). For accurately measuring the output of RF generators or for checking the accuracy of the instrument against a standard, such as the Ballantine Micropot, it is recommended that the bridging tee be attached directly to the micropot with the open end of the tee terminated by a precision N type (50Ω) termination.

2-5 LIST OF THE INSTRUMENTS' CONTROLS (See Fig. 2-1 & 2-2 on Page 9)

A. Front Panel Controls

1. Range Selector Switch. This switch facilitates selection of any one of the eight RF voltage ranges of the instrument.
2. Probe Input Connector. A 9-pin Amphenol type connector serves as connector for RF probe.
3. Set-Ref Adjustment. This control is used to adjust the pointer to the reference point with zero input signal on the lowest ranges. Should preferably be adjusted on the lowest range.
4. Power Switch. A 4-position ON-OFF-BAT.CHK-CHARGE switch.
5. Pilot Light. Indicates instrument is turned ON when line operated.
6. Mechanical Zero Adjust. Provided for mechanical zero adjustment of meter pointer.

B. Rear Panel Controls

1. DC Output Connector. This is a tip, ring, sleeve, phone-type output jack for DC output. 1.0 volt full scale is developed across a 2K load.
2. Power. Connector for the three conductor AC line cord.
3. Fuse Holder. This is a detachable bayonnet type holder, containing a 0.3 amp, "Slo-Blo" fuse.
4. Line Voltage Switch. Slide switch for either 115 or 230V AC operation.
5. Ballast Lamp. Current limiting device and battery fuse in charge circuit.

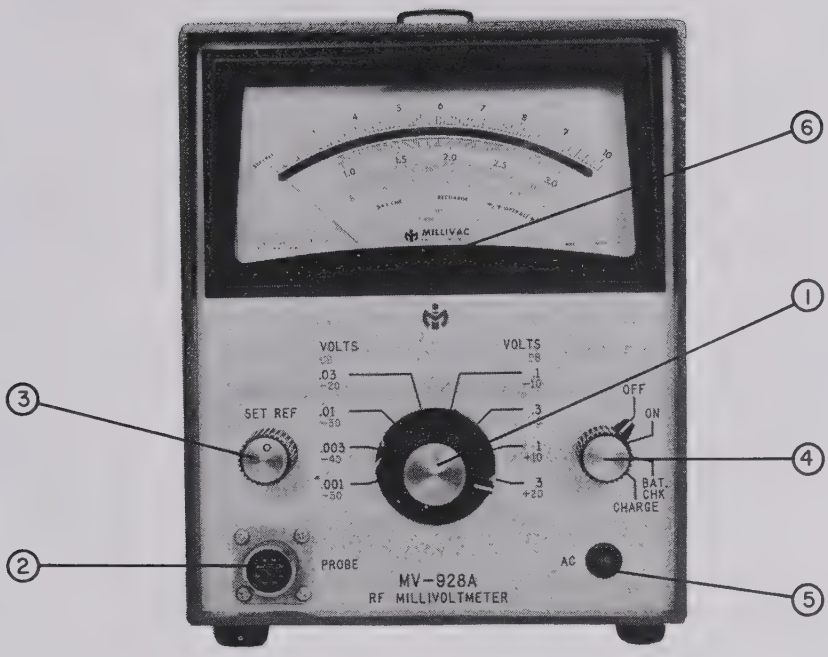


FIG. 2-1 FRONT PANEL CONTROLS

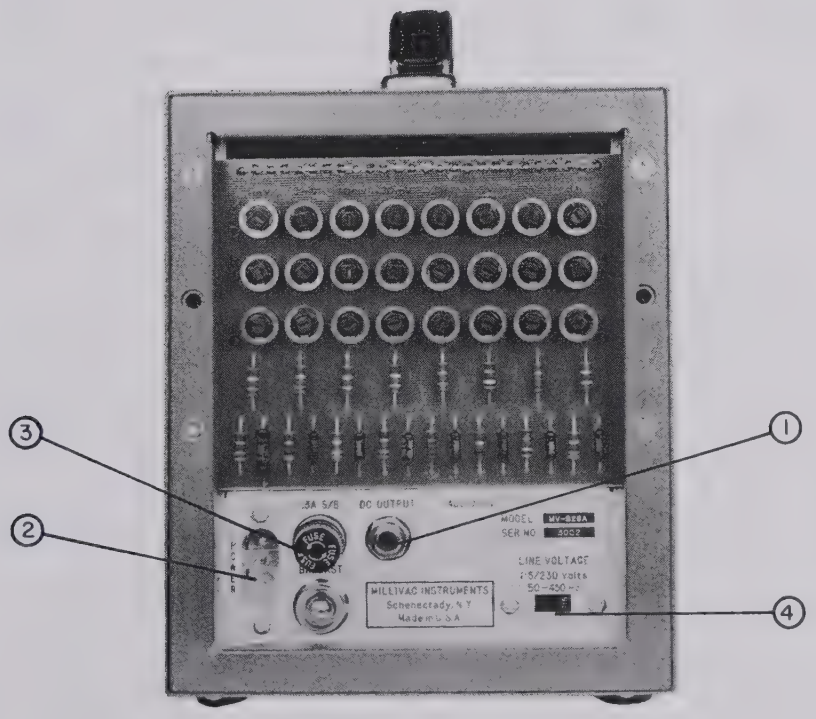


FIG. 2-2 REAR PANEL CONTROLS

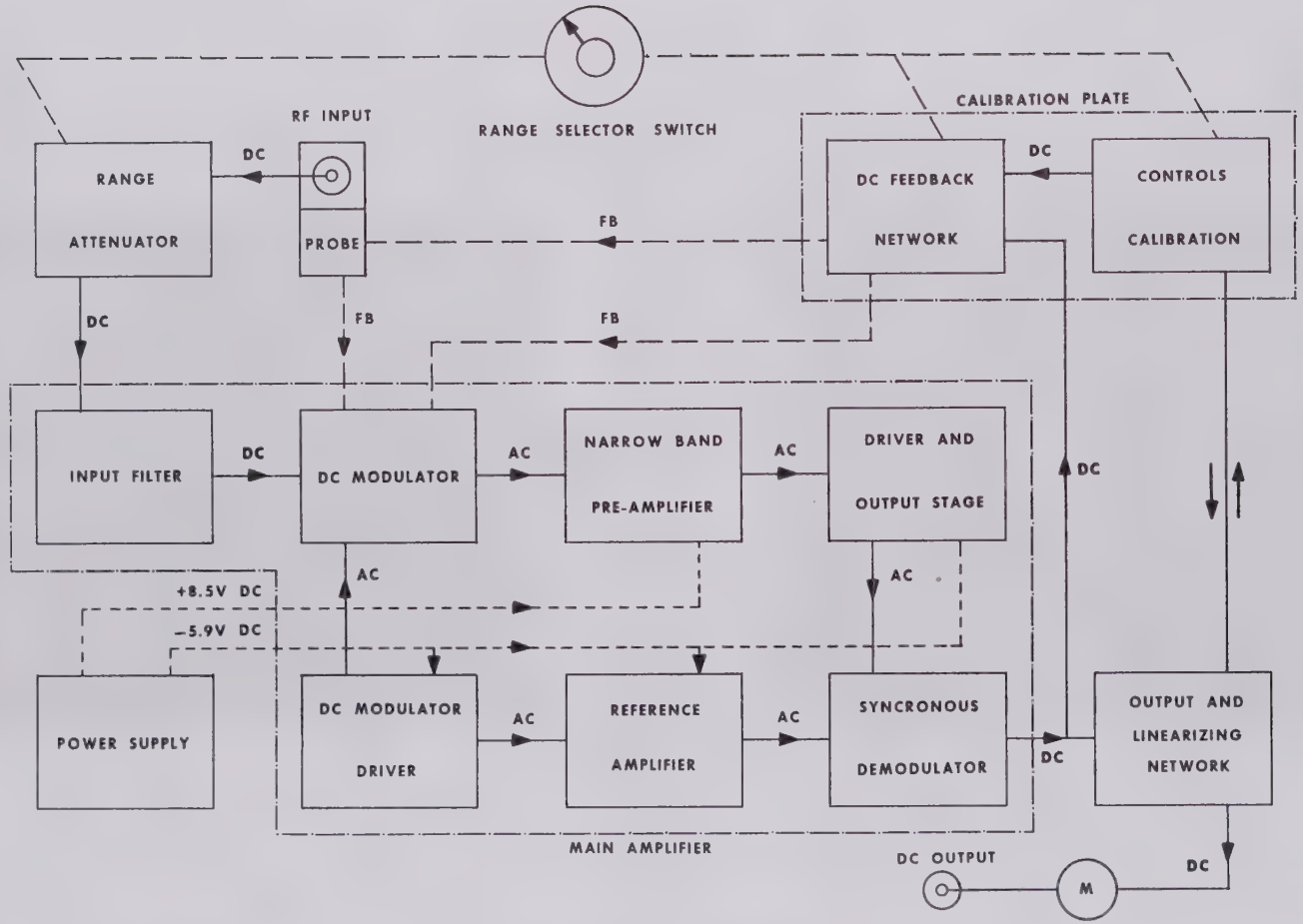


FIG. 3-1 BLOCK DIAGRAM

SECTION 3

DESCRIPTION OF CIRCUITRY

3-1 GENERAL

The basic circuitry of this instrument is best understood by reference to the block diagram, Fig. 3-1 on Page 10.

The RF signal is sampled and detected by the RF probe. The probe's DC output signal, after passing through the attenuator section of the range selector switch, goes through the Input Filter which rejects power line frequency components which might cause a measuring error. Next, a single-pole, double-throw DC Modulator converts the incoming DC signal into a nearly symmetrical square wave. The converted signal is then impedance matched and amplified by a high impedance narrow-band pre-amplifier. Its narrow bandwidth also improves the signal-to-noise ratio. The output of this stage is further amplified in the Driver and Output Stage.

Next, the AC signal is rectified by a Synchronous Demodulator and the resultant DC output is used to provide heavy overall DC feedback and temperature compensation. The DC output is also linearized in the Output circuit and used to drive the indicating meter. The DC Modulator is driven by a 2-transistor multi-vibrator circuit. The DC Modulator and its Driver determine the carrier frequency (in the order of 94Hz). The square wave output voltage of the Driver is sampled and amplified by the Reference Amplifier whose output is fed to the Synchronous Demodulator. The phase relationship between the Reference Amplifier signal and the carrier amplifier signal determines the polarity of the DC output. An electronically regulated Power Supply delivers a -5.9V and a +8.5V to the amplifier.

> NOTE: For the following detailed description of each circuit block, reference should be made to the complete circuit schematic for this instrument, attached at the end of this manual.

3-2 RF PROBE AND PROBE INPUT CIRCUIT

The RF probe contains a diode cartridge assembly (replaceable only as a unit). The cartridge assembly contains a coupling capacitor, two matched diodes, a pair of filter capacitors, and a pellet resistor. The sealed section of the RF probe housing contains two 10K RF filter resistors connected in series with the output terminals of the diode cartridge, and a temperature-sensing thermistor network connected in the DC feedback loop of the amplifier. The Thermistors are connected to the individual ranges by means of Section C and E of the range selector switch, S101. The individual pins of connector J101 are by-passed to ground by capacitors C103 through C107, thus preventing any possible error introduced by stray RF pick-up in the probe cable.

3-3 RANGE SELECTOR SWITCH

The range selector switch, S101 consists of Sections A through H. Sections A and B (Range Attenuator) contain resistive dividers supplying the full or partial voltage to the input of the amplifier, depending upon the range setting. This voltage, when modulated, amplified and demodulated, will indicate on the meter a reading corresponding to the value of the input signal within the accuracy rating of the range being used.

Section D disconnects R244 to provide additional gain on the two lowest ranges.

Sections C and E, in conjunction with Section H, form part of the DC feedback loop. Section H contains individual resistors and potentiometers to control the main feedback loop of each "Mid" range control. The thermistors, located in the RF probe, sense and correct for any thermal errors occurring as a result of the temperature characteristics of the RF diodes and are switched into the circuit through Section C and E.

Sections F and G switch in both resistors and potentiometers for correcting the non-linearity of the RF diodes.

3-4 INPUT FILTER

This circuit consists of R/C Networks and a tuned parallel "T" Network providing an effective AC filter with a minimum of 60db rejection at power line frequency.

3-5 DC MODULATOR (G201)

A 94Hz printed circuit plug-in DC modulator is employed. It modulates the DC input signal and the resultant AC component is impedance matched and amplified by the narrow-band preamplifier.

3-6 NARROW-BAND PRE-AMPLIFIER

The Narrow-band pre-amplifier features a low-noise, high-impedance input achieved by the use of a high quality field effect transistor (Q201). Diode CR201 forms a clamp circuit to protect the input transistor from excessive loverload. A three-stage conventional R/C coupled, common-emitter amplifier, consisting of Q202, Q203, and Q204, with the input transistor Q201, develop a gain of approximately 80db. A tuned, parallel "T" network in a negative feedback loop from the collector of Q204 to the base of Q202 narrows the amplifier bandwidth thus improving the signal-to-noise ratio. The supply voltage is held at +8.5V by Zener diode CR202.

3-7 DRIVER AND OUTPUT CIRCUIT

The Driver (Q205) and the Output Stage (Q206) are conventional capacitor coupled stages. The Amplifier Gain Control, R242 adjusts the level of signal applied to the base of Q205. R244 is disconnected on the two lowest ranges to allow additional gain. The signal developed in the output stage is applied to the Synchronous Demodulator, where rectification takes place. Before discussing this stage, an explanation of the DC Modulator Driver and Reference Amplifier is in order.

3-8 DC MODULATOR DRIVER

The Modulator Driver is a two-transistor multi-vibrator circuit, the frequency of which is adjusted via R264. The frequency is factory adjusted to 94Hz.

3-9 REFERENCE AMPLIFIER

The square wave output from the DC Modulator Driver is sampled by the amplifier stages via emitter followers, Q209 and Q210. The amplifiers, Q211 and Q212 amplify this square wave and it is coupled to the Synchronous Demodulator via T202.

3-10 SYNCHRONOUS DEMODULATOR

Q213 and Q214 are utilized in this phase-sensitive rectifying circuit. The signal from the output stage(Q205 and Q206) is compared with the reference signal from Q211 and Q212. The resultant DC output signal from this demodulator has a polarity corresponding to the original input signal polarity. In this type of operation, the collector current is a function of the collector voltage only, and is essentially independent from other transistor parameters. The voltage applied to the base of the transistor acts only as a phase-sensitive reference.

3-11 DC FEEDBACK AND CALIBRATION CONTROLS

A portion of the DC output voltage is fed back to the modulator to provide the excellent gain stability of the instrument. This feedback ratio is determined by values of a resistor and potentiometer connected in series and switched through Section H of the Range Selector Switch, S101. One of three thermistors mounted in the RF probe housing is switched in series with the previous combination by means of Section C and E of the Selector Switch. The DC feedback controls are marked "Mid" on the calibration plate and are used for accurate calibration of the mid-scale for each range. The appropriate feedback ratio is selected when switched to the desired range.

3-12 OUTPUT, LINEARIZING NETWORKS AND METER CIRCUIT

The DC output of the RF diode rectifiers is basically non-linear with respect to the RF input level. In order to achieve a linear output characteristic, correction networks are employed. Their function is to expand the lower end and compress the upper end of the meter scale. The networks consist of R102, R301, R302, R303, CR301 and CR302, as well as the resistors and potentiometers switched into the circuit by means of Section E and G of S101.

For better understanding of the circuitry, Fig. 3-2 shows all the details of the network as used on the 1mV range.

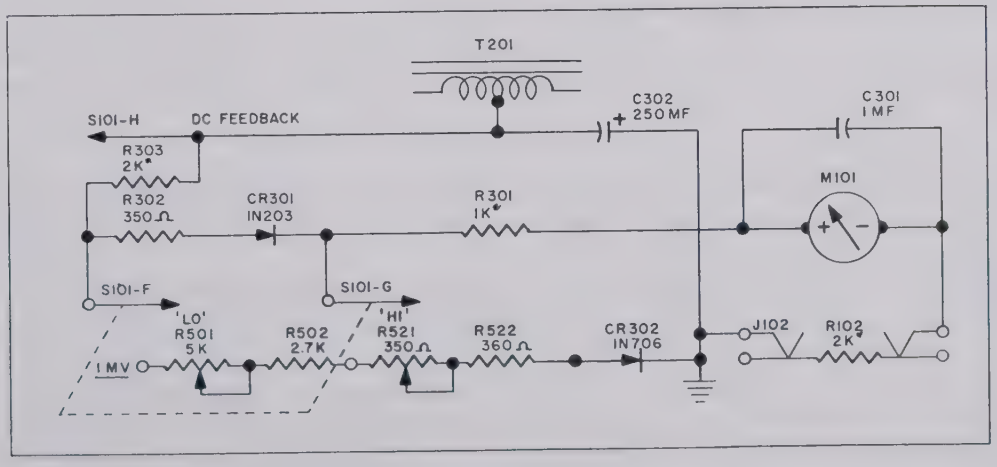


FIG. 3-2 SCALE CORRECTION NETWORK

The rectified DC, proportional to the DC input signal, appears at the center tap of the secondary T201 and filter capacitor, C302. For low input levels, 50% of full scale and lower, the signal passes through R303 R302, CR301 R301, M101 and R102. At low levels, the resistance of CR301 is fairly high and the current through the circuit is limited. By paralleling R302 and CR301 with R501 and R502, an exact adjustment of the meter to a point corresponding with the input voltage is possible.

For higher levels, 70 through 100% of full scale, R521, R522 and CR302 paralleled with M101, R102 and R301, provide adjustment of the meter to correspond with the incoming signal. To adjust the mid-scale point, the main DC feedback resistor (in the case of the 1mV range, R541) is utilized.

The indicating meter M101 is rated at 0-500 μ A DC

The resistor, R102, in series with M101, is connected to the circuit via J102. For external monitoring purposes, when a plug is inserted into J102, R102 is switched out of the circuit and the external monitor must provide the 2K series load. This value should be within ± 1% to maintain the rated calibration accuracy of the instrument.

3-13 REGULATED POWER SUPPLY

The electronically regulated power supply includes a 115/230V AC dual primary, power transformer (T601). Its secondary, in conjunction with the rectifiers (CR601, CR602), is used in a full-wave, center-tapped configuration. The rectifier output is applied to the collector of the series regulator transistor, Q601. The base of Q601 is biased by the temperature stable reference amplifier (Q602). The regulated output voltage appears at the emitter of Q601. An adjustable voltage divider across the output, consisting of R606, R608 and Potentiometer, R607, permits adjustment of the output voltage by determining the bias of the transistor portion of Q602.

SECTION 4

CALIBRATION

4-1 GENERAL

Calibration of the instrument is fairly simple, due to the fact that it is performed at a low frequency (approx. 200KHz). This is possible because of the construction and performance of the diode cartridge, which exhibits an even response through the entire frequency range (10Hz - 1.2Hz). The 200KHz calibration frequency was chosen mainly because it is in the portion of the total frequency range well above the 10KHz lower frequency limit of the meter and yet low enough to avoid possible calibration errors due to mistermination, standing waves, etc. It is, however, advisable, after the meter has been properly calibrated, to check its frequency response through the entire frequency range. (See Sec. 4-3G).

4-2 CALIBRATION PRECAUTIONS. (To avoid miscalibration, the following precautions should be observed)

A. Temperature Precautions. Although the probe is temperature compensated, it is recommended that the calibration be done at normal room temperature (75°F), thus assuring the most effective temperature compensation.

B. Hum Pick-Up. Adequate hum shielding for the input leads of the monitoring voltmeter must be provided particularly on the 1mV and 3mV ranges, or serious errors may be introduced. If the monitoring meter is equipped with jack input terminals, a General Radio (Type GR-274-QB5) shield should be used in conjunction with this test cord to provide adequate shielding.

C. Power Supply Voltage. It is recommended that the power supply be set at 14.4V before calibration. This should be measured between TP-64 and TP-61, with TP-61 being negative in respect to TP-64. All other voltage measurements are in respect to chassis ground (TP-62).

4-3 CALIBRATION PROCEDURE.

A. Calibration Equipment. Any signal generator, capable of supplying a low distortion (less than 2%) 200KHz sinusoidal signal, can be used to calibrate the instrument. To monitor the output of the generator, however, use an external AC voltmeter with an accuracy of ± 1% or better.

B. Calibration Controls. Remove the rear cover plate from the cabinet to allow free access to the HI, MID and LO calibration controls. See Fig. 2-2 on Page 9.

C. Mechanical Zero. Before turning on the instrument, adjust the mechanical zero screw to bring the meter pointer to the SET REF mark.

D. Electrical Zero. Adjustment is made by a front panel control marked SET REF. This adjustment should be made with the probe attached to the instrument and terminated with a 50 Ω termination with the signal source de-energized. Re-check electrical zero occasionally during the calibration procedure.

E. Range Calibration. A three-point calibration procedure is employed for this instrument. The calibration points are: 1, low end; 2, mid-scale; and 3, the high end of scale. On the ranges employing the 1 to 3 scale, these points correspond to scale readings of "1", "2", and "3" respectively, while on the 3 to 10 scale the points are "3", "6", and "10". These points for calibration purposes are designated as LO, MID and HI. Starting with the 1mV range, apply a 600μV, 200KHz signal (the MID scale point equivalent) to the instrument. Adjust the MID calibration control for the range selected to correspond to this input voltage. Next, apply a 300μV signal (corresponding to the LO scale point) and adjust the LO control accordingly. Finally, a 1mV signal (the HI scale value) is applied and the HI control adjusted. Due to the fact that some inter-action of the three controls takes place, this procedure should be repeated until proper tracking occurs at the three scale points. This procedure should be followed on the remaining ranges. Be certain to re-adjust the SET REF control before calibrating each range.

F. Scale Distribution. A close check at points other than the three calibration points may reveal some errors in the tracking accuracy of the meter. This situation will exist to a minor degree on almost all ranges of the instrument due to the basic non-linear response of the probe, as well as the non-linear correction network of the output circuit. However, the method described under Sec. 4-3E provides a tracking accuracy that is within the over-all specifications of the meter.

G. Frequency Response Check. To check the frequency response of the instrument, it will be necessary to use four signal generators to cover the entire frequency range of the instrument (10KHz - 1.2GHz). Care has to be taken to properly terminate the generators and line to avoid mistermination and standing wave errors.

A. For the frequency range 10KHz to 10MHz use the HP-200SR and HP-739AR or equivalent Generators. Use a conventional method to check the frequency response.

B. For the frequency range 10MHz to 600MHz use the HP-608C and HP-612A Generators or equivalent. Set the modulator Selector to CW. At each frequency to be checked feed the output of the Generator into the HP-431 Power meter or equivalent and adjust that output to 0-DBM. With the 50Ω BNC Termination on the Probe, attach the RF Voltmeter to be checked in place of the Power meter. The reading on the RF Voltmeter should be within its rated accuracy.

C. For the frequency range from 600MHz to 1.2GHz use the HP-612A Generator and the HP-431 Power meter or equivalent. Set up equipment as shown in Fig. 4-1. Set modulator selector switch to CW. Adjust the Generator output to 0-DBM on the Power meter. The reading on the RF Voltmeter should be within its rated accuracy.

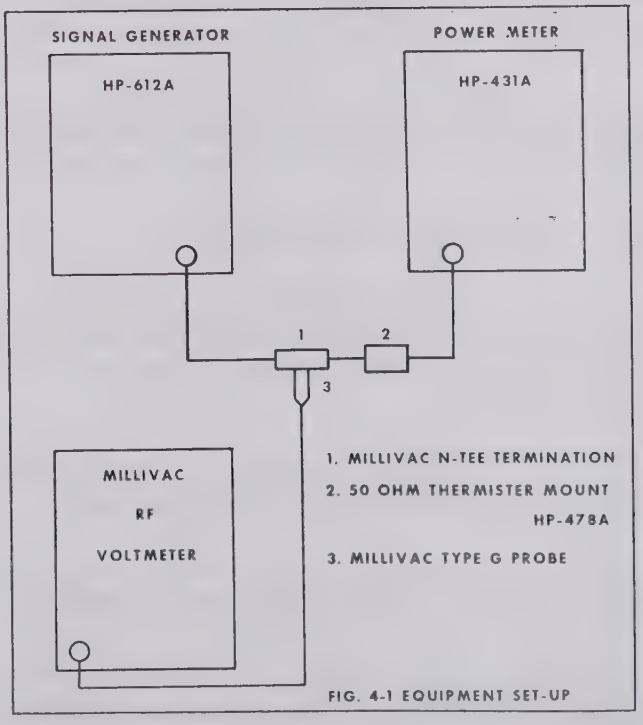


FIG. 4-1 EQUIPMENT SET-UP

4-4 CALIBRATION PROCEDURE FOR THE 100:1 CAPACITIVE DIVIDER (See Fig. 4-2)

After the RF Voltmeter has been carefully calibrated, insert the 100:1 divider between the 50Ω termination and the RF probe. Set the range selector at 30mV and feed a 3V, 200KHz signal into the probe and observe the meter reading. A properly calibrated divider will attenuate the RF signal exactly 100 times, resulting in a meter indication of 30mV. Any deviation from this reading can be corrected by slight adjustment of the hexagonal center contact screw at the front end of the divider. Always remove the termination each time an adjustment is made. Turning the screw in a clockwise direction will increase the meter reading. It is recommended that a #6 (3/16") hexagonal nut driver be used for this adjustment.

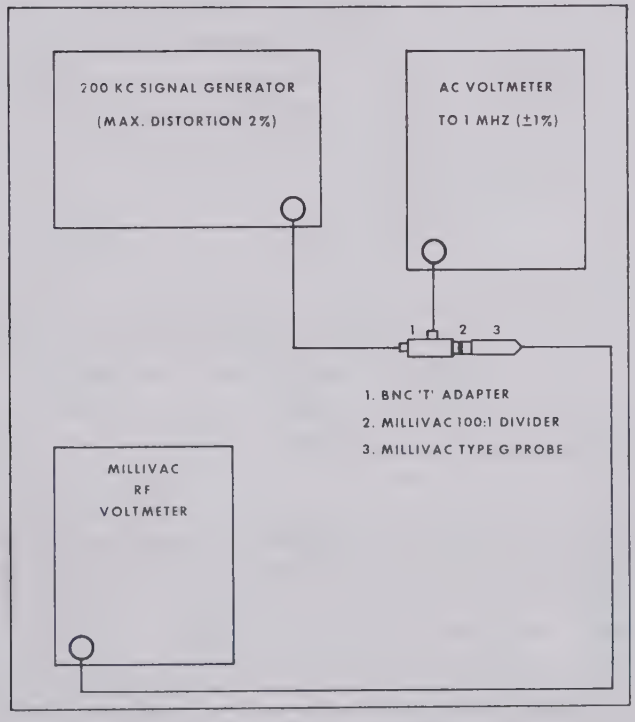


FIG. 4-2 CALIBRATION EQUIPMENT SET-UP

4-5 CALIBRATION PROCEDURE FOR THE N-"TEE" BRIDGING ADAPTER (See Fig. 4-3)

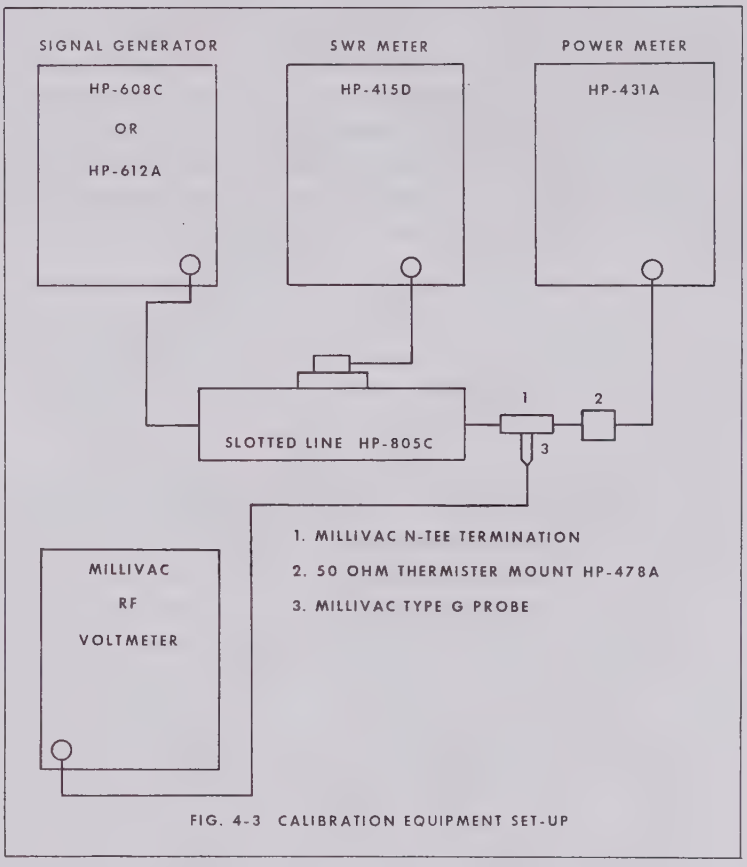


FIG. 4-3 CALIBRATION EQUIPMENT SET-UP

With equipment set up as shown in Figure 4-3, set the Signal Generator to 1.2GHz. Set modulation to 1000Hz. Modulation amplitude to 40%. RF output to 0-DBM. Tune the slotted line for a maximum reading on the SWR meter, then set SWR meter to full scale. Now, adjust the slide on the slotted line for a null on the SWR meter. The reading should be less than 1.2:1 (typically 1.1:1).

The Millivac N-"Tee" will be better than 1.2:1 with any cartridge, but for the best VSWR the N-"Tee" should be adjusted to the cartridge that it will be used with. This is accomplished by following the above procedure and then adjusting the two Allen head screws on the input connector of the N-"Tee" for best VSWR. The N-"Tee" should then be checked with the generator, set at 600MHz. The VSWR at 600 MHz should again be less than 1.2:1.

SECTION 5

MAINTENANCE

5-1 GENERAL

The following sections describe the normal maintenance procedure for both the instrument and the RF probe and accessories.

5-2 MAINTENANCE OF THE RF PROBE AND ACCESSORIES

5-2.1 RF Probe Cartridge Replacement

Replacement of the probe cartridge as a result of diode failure, due to excessive RF input, will probably be found to be the most frequency cause for service.

If the instrument does not respond to RF signals, but in other respects appears to be operating normally, the probe cartridge should be suspected. A simple check of the amplifier portion may be made by switching the instrument to its lowest range and rotating the SET REF control fully clockwise. The indicating meter should read approximately full scale if the amplifier is operating normally. A further check can be made by disconnecting the cable from the front panel. This should cause the pointer to drift off-scale in either direction as long as the range selector is in the 1mV position. When switched to the 3V position, the instrument should recover rapidly, with the pointer coming to rest at its SET REF position.

If the cartridge is suspected, a single resistance measurement of the diodes may be made after removal of the cartridge from the probe housing (see Fig. 5-1). This can be achieved by removal of the exposed set screw on the side of the probe housing. The cartridge may now be pulled out of the housing. Two small spring contacts will be noted on the end of the cartridge. Care should be exercised so as not to damage these contacts. By placing an ohmmeter across the contacts, a forward-reverse resistance ratio may be measured. Using a Simpson 260-VOM in its highest resistance range, a resistance ratio of approximately 800 times should be noted with about 5K in the forward direction. Any other reading would indicate a faulty cartridge.

The spring should be removed from the probe housing and may be re-used if it is clean and not damaged. During manufacture, a thin, protective grease film has been applied to all silver-plated surfaces to retard oxidation. Care should be exercised to avoid removal of this film. If the film has inadvertently been removed, or if the contacts inside the probe housing have been cleaned, a thin film of white vaseline may be applied to the surfaces. The cartridge should be carefully inserted into the housing, making certain that the slot in the side of the cartridge is aligned with the locking-screw hole in the side of the probe housing. The

locking screw may now be inserted and tightened, taking care that it properly engages the cartridge slot. Finally, the grounding spring is inserted, noting the correct spring position, as shown in Fig. 5-1. Positioning the spring may be facilitated by gently pushing the cartridge all the way into the housing several times. When the spring is in its correct position, the fingers will be flush with the edge of the probe housing. With a little thumb pressure, the cartridge should slide smoothly back and forth against the spring-loaded socket assembly inside the probe housing. If it binds and does not return fully after being depressed, the grounding spring fingers may be holding it too tightly. Should this happen, the spring should be removed and the fingers flattened very slightly, pinching them between the smooth areas of a pair of long-nosed pliers.

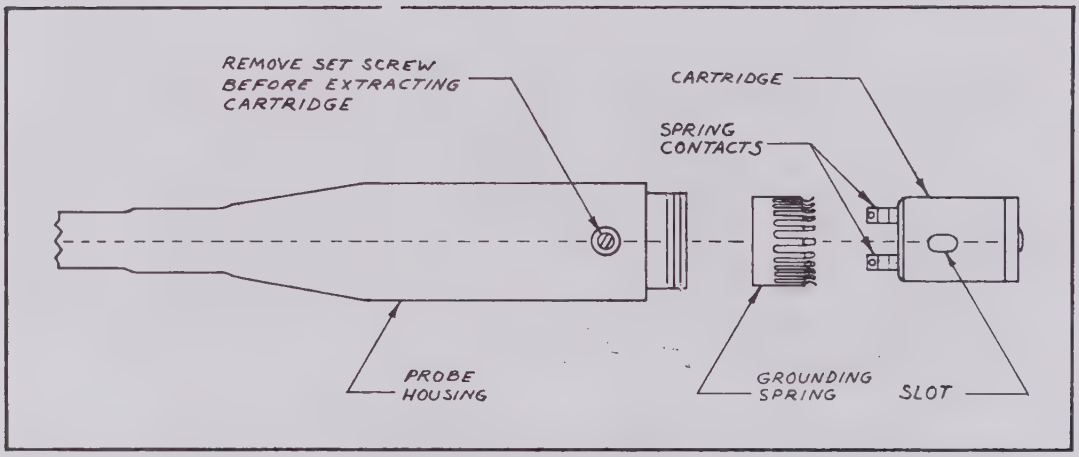


Fig. 5-1 Probe Cartridge Assembly

5-2.2 RF Probe Maintenance

The RF probe housing assembly is carefully manufactured and factory sealed. It is not recommended that the housing be dis-assembled. If it is found to be defective, it should be returned to the factory for repair. Warranty on the RF probe housing is void if it is tampered with. The probe housing may be checked out with an ohmmeter. The Millivac MV-864A or MV-279C is recommended for this purpose because of their accuracy and negligible power dissipation across the resistance to be measured. Assuming the probe and cable have been disconnected from the instrument, the RF cartridge should be removed before making the following measurements.

TABLE 1 PROBE RESISTANCE MEASUREMENTS

Location	Resistance
P101A to P101B	Approx. 10K
P101A to P101C	" 100K
P101A to P101D	" 500K
(The above thermistor values are ±20% at 72°F)	
P101A to probe housing	Infinity
P101H to probe #1 terminal	10K ±10%
P101J to probe #2 terminal	10K ±10%
P101H to P101J	Infinity
P101H to probe housing	"
P101J " " "	"
P101E " " "	Less than 1Ω
P101F " " "	" " "
P101K " " "	" " "

Any discrepancies in the above resistance checks indicate a defect in the probe housing assembly and it should be returned to Millivac for repair.

5-2.3 Probe Accessories

A. General. Maintenance is either self-explanatory or minor on most of the probe accessories available from Millivac. However, certain points of information noted here may be of value in the maintenance of these accessories. The center pins of all probe accessories should make contact within at least 1/16" of the fully threaded position.

B. High Impedance Tip. Check that the center pin is correctly positioned to make proper contact with RF probe center contact. Check the ground wire and clip for continuity.

C. Termination. Check the DC resistance value of the film resistor. The termination leaves the factory at ±2% of stated value. If it is found to be out of tolerance, it is recommended that a new termination assembly be ordered from Millivac. See Section 6 for part number.

D. N "Tee" Bridging Adapter. These units are adjusted during manufacture for minimum VSWR and should not be dis-assembled. They should be returned to the factory for repair.

E. 100:1 Capacitive Divider. Refer to calibration section for proper calibration of this unit. Damaged units are not readily serviced in the field. Return them to the factory for repair.

5-3 MAINTENANCE OF THE INSTRUMENT

5-3.1 Cabinet Removal

Should the instrument require repairs which necessitates its removal from the cabinet, remove the two Phillips 6-32 binder head screws located on the bottom rear of the cabinet. Then slide the chassis to the rear and out of the cabinet.

5-3.2 General Trouble Shooting

A. In case the instrument fails to operate, investigation of the line cord and fuse should be made.

B. The fuse is located at the rear of the instrument (See Fig. 2-2 on Page 9). Replace only with a "Slo-Blo" type of the correct rating, as marked on the rear nameplate above the fuse holder. Be certain that the line voltage switch, also located on the rear panel, is set to the correct position before operating.

C. If the instrument is not functioning properly and requires trouble shooting, the DC Modulator and transistors should be checked first, preferably by substitution. When checking the transistors by substitution, replace only with units of the same type and manufacture. Transistor Q201 may be ordered directly from Millivac, as well as the chopper G201. When the instrument is turned on, the Modulator should produce a continuous audible 94Hz tone. If no tone is evident, the Modulator or driver circuit may be defective. Important static voltage values and waveshapes with peak-to-peak voltage values are shown on the circuit schematic.

5-3.3 Signal Tracing

Assuming that a routine investigation by substitution has confirmed that the DC Modulator and all transistors are good, signal tracing is the next approach.

Recommended service equipment consists of:

1 - DC Multimeter, Millivac MV-864A or equal
1 - Tektronix Model 503 scope or equal
1 - AC TRVM (RMS), Millivac MV-45A or equal
1 - 200KHz Signal Generator HP/606A or equal

When operating the instrument removed from its cabinet, care must be exercised to avoid power line hum pick-up in the DC Modulator and pre-amplifier circuits. Excessive pick-up will prevent making correct gain and waveshape measurements. If pick-up is a problem, aluminum plates placed on the bottom, top, and sides of the instrument will effectively shield it.

Be certain that the power supply voltage is set at 14.4 volts before making any gain measurements. The 14.4V should be measured between TP-64 and TP-61 with TP-61 being negative in respect to TP-64.

A. Checking Waveshape of Complete Amplifier. If the meter is operative at all, although somewhat erratic or intermittent, improper modulator action or other amplifier weaknesses may be detected by observation of the modulated and amplified signal at the secondary winding of the output transformer test point, TP24 or TP26 and chassis ground (see circuit schematic). A check of the output waveshape can be made by feeding a 1mV, 200KHz, RF signal into the probe with the range switch at the 1mV position. Wihtout the RF input signal and the instrument properly zeroed to the SET REF position, the waveshape appears as shown on the circuit schematic - main amplifier. The residual signal appearing in the zero-signal waveshape is not entirely amplifier noise. Its spikes and depressions are caused by the 94Hz reference signals impressed upon the bases of Q213 and Q214. Any drastic deviation of either waveshape indicates a faulty amplifier. Improper adjustment of the zero control, SET REF, may result in large deviations from the waveshapes illustrated.

The reference amplifier output signal must be of the correct amplitude and waveshape for proper operation. The waveshape can be observed across TP27 and TP28. The waveshape and amplitude should agree closely with that shown on the schematic.

B. Checking Modulator and Narrow-Band Pre-Amplifier Stages. Locate test points, TP22 and TP23 on main amplifier board and unsolder the jumper connected between them. This disconnects the output of the pre-amplifier from the main amplifier. The waveshape of the amplified and modulated signal at TP22 can be observed, as seen on the schematic. The instrument should be in the 1mV position with the meter pointer adjusted to the SET REF point.

Two waveshape values are shown. One is with zero-input signal while the other is with a 1mV RF signal applied to the input of the probe. With 1mV RF input, the output of the pre-amplifier should be approximately 800mV, peak-to-peak at 94Hz and should be essentially a sine wave. Any drastic deviation in amplitude and waveshape indicates an abnormality in this portion of the instrument. Transistors are checked best by substitution. Be certain to replace only with units of the same type and manufacture.

If after changing components, the gain is still low it may be necessary to tune the frequency adjust R264 for a maximum output at TP22.

C. Checking the Main Amplifier. With the amplifier set up as in 5-3.3B, disconnect one end of diode CR302 (glass diode located on input-output board). A test set-up as shown in Fig. 5-2 should be constructed which furnishes the necessary input signal to drive the meter to full scale on the 1mV range. In making this measurement, the Reference Amplifier must be functioning properly with the correct output amplitude and waveshape as shown on schematic. With the test source switched off, carefully adjust the SET REF control to zero the meter at the correct input signal to the main amplifier via TP23 and the junction of R246 and R248. The meter should now slowly move upscale and if the amplifier has the correct gain, the meter will read approximately full scale. If the reading is in error by more than ±10% of full scale, the amplifier gain control, R242 can be adjusted for a full scale meter reading. This adjustment should occur at a point between 25% and 75% of the control's rotation. If excessive gain is necessary or the meter cannot be made to read full scale, it indicates a faulty amplifier and the transistors in the associated circuit should be checked. It is important to replace only with the same type and manufacture.

When the above adjustments are correct, the instrument can be restored to its normal condition by resoldering the jumper lead between test point TP22 and TP23 and resoldering diode CR302. The calibration should now be checked before placing the instrument back in service.

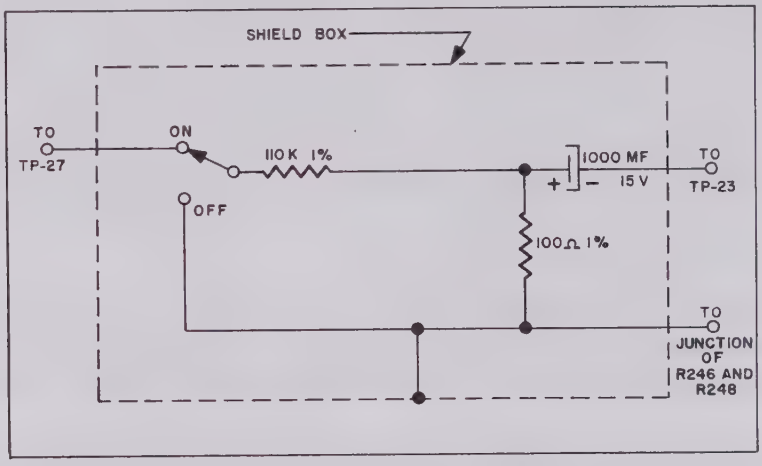


FIG. 5-2 TEST SET-UP

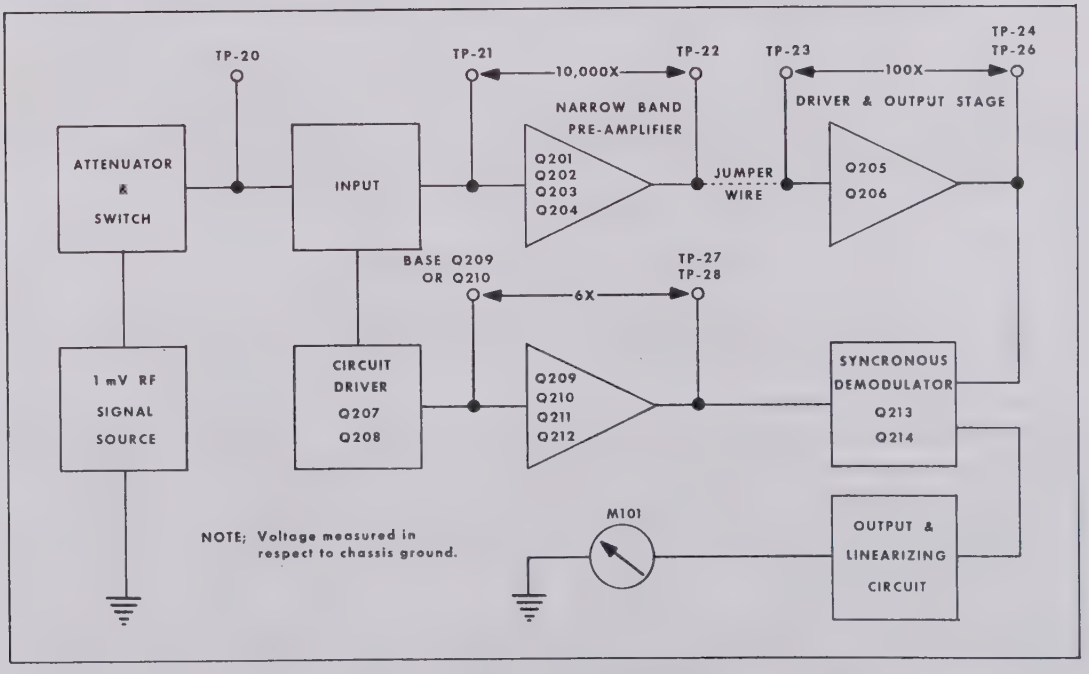


FIG. 5-3 AMPLIFIER GAIN DIAGRAM

5-3.6 Power Supply

A. Line Operation. The output of the power transformer, T601 is rectified by diodes CR601 and CR602 in a full-wave, center-tapped configuration. The resultant DC is limited by R603 and regulated by the series transistor, Q601. The adjustable voltage divider, R606, R608, and potentiometer R607 sets the bias on the voltage Reference Amplifier, Q602 whose output controls the bias on Q601, the series regulator. The output of the power supply can be varied from approximately 11 volts to 18 volts by R607. The Power Supply Voltage should always be set to 14.4V between Tp-64 and TP-61 with TP-61 being negative in respect to TP-64. All other voltage measurements are made in respect to chassis ground. With the instrument as the only load (approximately 95mA) and the voltage properly adjusted, the power supply should regulate with as little as approximately 80 volts AC input. When measuring the power supply ripple with an oscilloscope, be certain the line voltage is near 117 volts AC. The ripple voltage waveshape is shown on the schematic. The scope should be connected to TP-61 with the ground connection at TP-64.

B. Battery Operation. The internal nickel-cadmium batteries are trickle charged during line operation of the instrument. In battery operation the instrument will operate a minimum of 8-hours and it can be recharged overnight. Many charges and re-charges can be performed. WARNING: Do not allow the batteries to discharge below the "operate" point on the meter scale.

SECTION 6

REPLACEABLE PARTS LIST

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
A1 thru			
A100	Not assigned		
A101	Ass'y, Probe cartridge (Part of P101)	900-2004B	
A102	Ass'y, Termination adapter, 50Ω BNC	900-2050A	
A103 thru			
A200	Not assigned		
A201	Ass'y, etched circuit board, Main Amplifier	450-1055B-1	
A202 thru			
A500	Not assigned		
A501	Ass'y, etched circuit board, calibration controls	450-1059A	
A502 thru			
A600	Not assigned		
A601	Ass'y, etched circuit bd, power supply & output board	450-1060A-1	
A601+	Ass'y, etched circuit bd, power supply & output board	450-1060A-2	
BT1 thru			
BT100	Not assigned		
BT101+	Ass'y, Battery	460-1001	
C1 thru			
C100	Not assigned		
C101 &			
C102	Capacitor, ceramic, disc, .01μfd, 1000V	610-1017	Centralab C1-103
C103 thru			
C111	Capacitor, ceramic, disc, .002μfd, 1000V	610-1006	Centralab DD202
C112 thru			
C200	Not assigned		
C201 &			
C202	Capacitor, paper, mylar, .01μfd, 200V	621-1024	TRW663UW
C203	Capacitor, paper, metalized, .15μfd, 100V ±5%	630-1015	Midwec 7F
C204	Capacitor, paper, metalized, .3μfd, 100V ±5%	630-1018	Midwec 7F
C205	Same as C203		
C206	Capacitor, paper, metalized, .1μfd, 100V ±20%	630-1033	Midwec 7F
C207 &			
C208	Same as C103		
C209 &			
C210	Not assigned		
C211	Capacitor, polystyrene, .01μfd, 400V	622-1022	Arco 4PT-103K
C212	Capacitor, electrolytic, 2000μfd, 16V	635-1026	Whale 34-750-2000-16-6PC

+Used in Model MV-928A only

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
C213 & C214	Capacitor, electrolytic, 100µfd, 16V	635-1017	Richey 14-437-100-16C
C215	Same as C206		
C216 thru C220	Same as C213		
C221	Same as C203		
C222	Same as C204		
C223	Same as C203		
C224 thru C240	Not assigned		
C241 thru C243	Same as C213		
C244	Capacitor, mylytic, 1.0µfd, 50V	621-1026	Whale MYL-22-375-1-50C
C245 thru C260	Not assigned		
C261 & C262	Capacitor, Tantalum, 3.3µfd, 35V	632-1012	Sprague 150D33-5X9035B0
C263 & C264	Same as C213		
C265	Capacitor, paper, mylar, 0.1µfd, 600V	621-1004	Sprague 6PS-P10
C266	Same as C103		
C267 thru C300	Not assigned		
C301	Capacitor, paper, metalized, 1.0µfd, 200V	630-1005	Sprague 155P1050
C302	Capacitor, electrolytic, 250µfd, 12V	635-1011	Sprague 31D115
C303 thru C600	Not assigned		
C601A&B	Capacitor, electrolytic, 250-250µfd, 50V	635-1016	Richey 32-750-250 250-50C com.pos
C602	Not assigned		
C603	Same as C212		
C604	Capacitor, electrolytic, 1000µfd, 16V	635-1025	Whale 30-625-1000-16-6PC
CR1 thru CR200	Not assigned		
CR201	Diode	101-2003	
CR202	Diode, VR8.5A	101-2010	VR8.5A
CR203 thru CR260	Not assigned		
CR261 & CR262	Diode, ED90	101-2007	ED-90

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
CR263 thru			
CR300	Not assigned		
CR301	Diode, IN203	101-0203	IN203
CR302	Diode, IN706	101-2001	IN706
CR303 &			
CR304	Diodes, IN91	101-0091	IN91
CR305 thru			
CR600	Not assigned		
CR601 &			
CR602	Diodes, IN2482	101-2000	IN2482
CR603+	Same as CR601		
DS1 thru			
DS100	Not assigned		
DS101	Lamp, Pilot AC	800-3003	Int. Prods. R6
F1 thru			
F100	Not assigned		
F101	Fuse, cartridge, S-B, 3/10 Amp	800-1006	Bus-MDL
G1 thru			
G200	Not assigned		
G201	Chopper, electro-mechanical, S.P.D.T., 94Hz	700-1008	
J1 thru			
J100	Not assigned		
J101	Connector, chassis, female, INPUT	800-7220	Amphenol 165-16
J102	Jack, Telephone, OUTPUT	800-7500	Switchcraft 24-SF
J103 &			
J104	Not assigned		
J105	Connector, power, Male, 3-Pin	800-7406	Switchcraft AC3G
M1 thru			
M100	Not assigned		
M101	Meter, indicating, 0-500μA (MV-828A)	203-1105A	
	Meter, indicating, 0-500μA (MV-928A)	203-1104B	
P1 thru			
P100	Not assigned		
P101	Probe (Type G) including housing, cartridge, cable and connector	900-2000B	
P102 &			
P103	Not assigned		
P104	Cord set, line, power, removable	800-5121	Belden 17258S

+Used in Model MV-928A only

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
P105	Part of P104		
Q1 thru			
Q200	Not assigned		
Q201	Transistor, Si, NPN	100-1012	
Q202 thru			
Q204	Transistor, Ge, PNP, 2N414	100-1004	2N414
Q205 &			
Q206	Transistor, Ge, PNP, 2N1414	100-1008	2N1414
Q207 &			
Q208	Transistor, Ge, PNP, 2N1373	100-1015	2N1373
Q209 thru			
Q214	Same as Q205		
Q215 thru			
Q600	Not assigned		
Q601	Transistor, Ge. PNP, MHT 3030	100-1016	MHT3030
Q602	Transistor, SI, RA1	100-1010	RA1
R1 thru			
R100	Not assigned		
R101	Resistor, variable, comp, linear taper, 1M ±10%, 1/2W	580-1030	
R102	Resistor, fxd, metal film, 2K ±1%, 1/4W	512-2001	
R103 thru			
R200	Not assigned		
R201 thru			
R203**	Resistor, fxd, metal film, 20K ±1%, 1/4W	512-2002	
R204**	Resistor, fxd, metal film, 10K ±1%, 1/4W	512-1002	
R205** &			
R206	Same as R201		
R207	Resistor, fxd, WW, 25Ω ±1%, 1/2W	508-25R0	
R208	Resistor, fxd, metal film, 1K ±1%, 1/4W	512-1001	
R209 &			
R210	Not assigned		
R211	Resistor, fxd, metal film, 600Ω ±1%, 1/4W	512-6000	
R212	Same as R204		
R213	Resistor, fxd, metal film, 82K ±1%, 1/4W	512-8202	
R214	Resistor, fxd, metal film, 820Ω ±1%, 1/4W	512-8200	
R215	Resistor, fxd, metal film, 3.33K ±1%, 1/4W	512-3331	
R216	Same as R204		
R217	Same as R213		
R218	Same as R214		
R219	Same as R215		
R220	Same as R204		
R221	Same as R213		
R222	Same as R214		

** Selected in manufacture; nominal value listed

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
R223	Same as R215		
R224**	Resistor, fxd, metal film, 12K ±1%, 1/4W	512-1212	
R225**	Resistor, fxd, metal film, 6K ±1%, 1/4W	512-6001	
R226**	Same as R224		
R227	Same as R213		
R228 thru R240	Not assigned		
R241	Resistor, fxd, comp, 110K ±10%, 1/2W	500-114	
R242	Resistor, var, carbon, linear taper, 10K ±30%, 1/4W	580-1049	
R243	Resistor, fxd, comp, 1K ±10%, 1/2W	500-102	
R244	Resistor, fxd, comp, 620Ω ±10%, 1/2W	500-621	
R245	Resistor, fxd, comp, 2K ±10%, 1/2W	500-202	
R246	Resistor, fxd, comp, 10K ±10%, 1/2W	500-103	
R247	Resistor, fxd, comp, 82K ±10%, 1/2W	500-823	
R248	Same as R243		
R249	Resistor, fxd, comp, 4.7K ±10%, 1/2W	400-472	
R250	Same as R246		
R251	Same as R247		
R252	Resistor, fxd, WW, 8.2Ω ±10%, 2W	510-8R2	
R253 thru R260	Not assigned		
R261 & R262	Same as R102		
R263**	Resistor, fxd, metal film, 150Ω ±1%, 1/4W	512-1500	
R264	Resistor, var, WW, linear taper, 75Ω ±20%, 2W	580-1055	
R265	Resistor, fxd, comp, 27Ω ±10%, 1/2W	500-270	
R266	Same as R247		
R267	Same as R246		
R268	Same as R247		
R269	Same as R246		
R270	Resistor, fxd, comp, 2.7K ±10%, 1/2W	500-272	
R271	Resistor, fxd, comp, 270Ω ±10%, 1/2W	500-271	
R272	Same as R270		
R273	Same as R271		
R274 & R275	Resistor, fxd, WW, 2.2Ω ±10%, 2W	510-2R2	
R276	Resistor, fxd, comp, 27K ±10%, 1/2W	500-273	
R277	Same as R247		
R278	Same as R276		
R279	Same as R247		
R280 thru R299	Not assigned		
R300+	Resistor, fxd, metal film, 28K ±10%, 1/4W	512-2802	
R301	Same as R208		

**Selected in manufacture; nominal value listed
+Used in Model MV-928A only

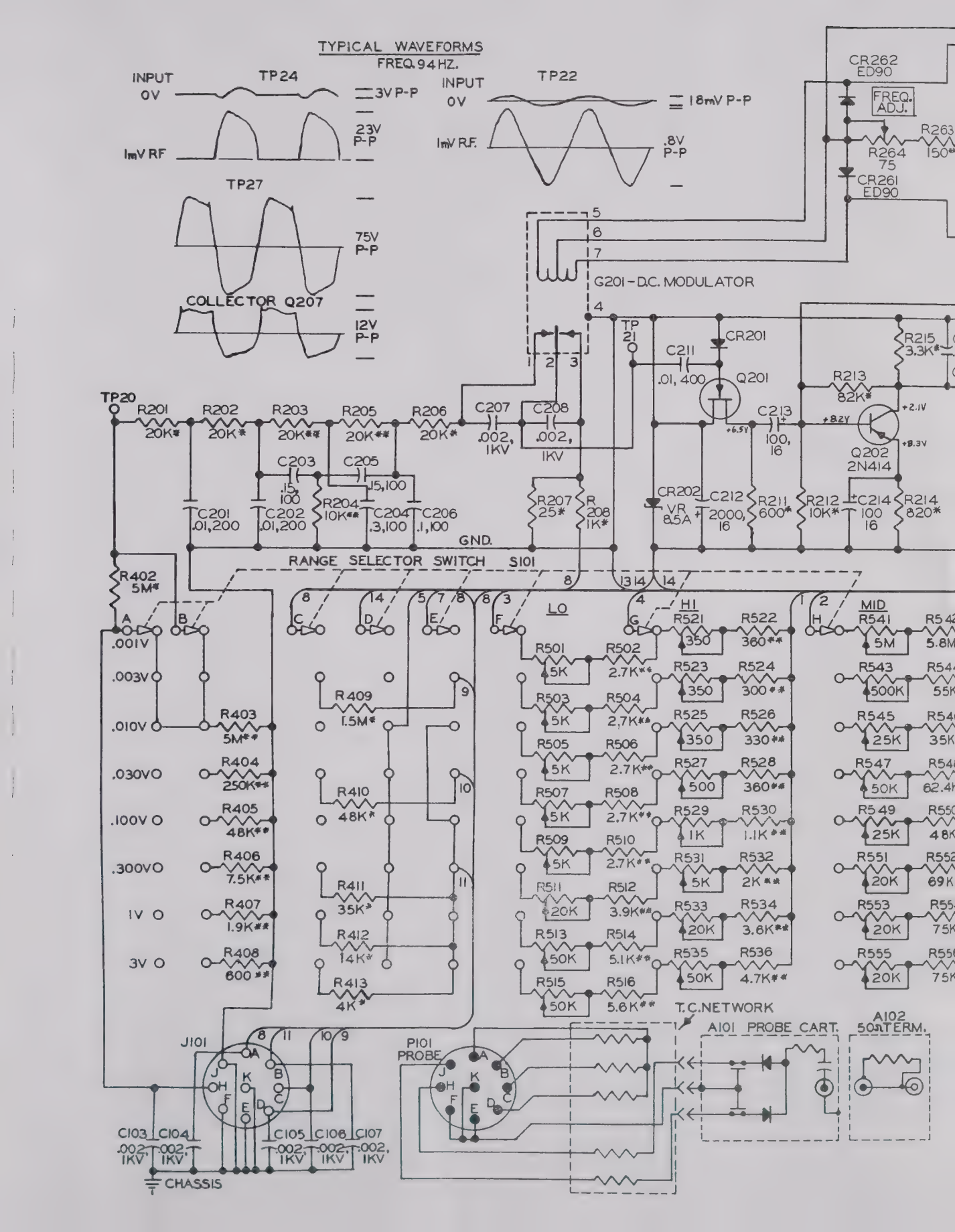
CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
R302	Resistor, fxd, metal film, 350Ω ±1%, 1/4W	512-3500	
R303	Same as R102		
R304 thru R401	Not assigned		
R402 & R403	Resistor, fxd, carbon film, 5M ±1%, 1/2W	520-5004	
R404**	Resistor, fxd, metal film, 250K ±1%, 1/4W	512-2503	
R405**	Resistor, fxd, metal film, 48K ±1%, 1/4W	512-4802	
R406**	Resistor, fxd, metal film, 7.5K ±1%, 1/4W	512-7501	
R407**	Resistor, fxd, metal film, 1.9K ±1%, 1/4W	512-1901	
R408**	Same as R211		
R409	Resistor, fxd, metal film, 1.5M ±1%, 1/4W	512-1504	
R410	Same as R405		
R411	Resistor, fxd, metal film, 35K ±1%, 1/4W	512-3502	
R412	Resistor, fxd, metal film, 14K ±1%, 1/4W	512-1402	
R413	Resistor, fxd, metal film, 4K ±1%, 1/4W	512-4001	
R414 thru R500	Not assigned		
R501	Resistor, var, comp, linear taper, 5K ±20%, 1/4W	580-2003	
R502**	Same as R270		
R503	Same as R501		
R504**	Same as R270		
R505	Same as R501		
R506**	Same as R270		
R507	Same as R501		
R508**	Same as R270		
R509	Same as R501		
R510**	Same as R270		
R511	Resistor, var, comp, linear taper, 20K ±20%, 1/4W	580-2004	
R512**	Resistor, fxd, comp, 3.9K ±10%, 1/2W	500-392	
R513	Resistor, var, comp, linear taper, 50K ±10%, 1/4W	580-2006	
R514**	Resistor, fxd, comp, 5.1K ±10%, 1/2W	500-512	
R515	Same as R513		
R516**	Resistor, fxd, comp, 5.6K ±10%, 1/2W	500-562	
R517 thru R520	Not assigned		
R521	Resistor, var, comp, linear taper, 350Ω ±20%, 1/4W	580-2000	
R522**	Resistor, fxd, comp, 360Ω ±10%, 1/2W	500-361	
R523	Same as R521		
R524**	Resistor, fxd, comp, 300Ω ±10%, 1/2W	500-301	
R525	Same as R521		
R526**	Resistor, fxd, comp, 330Ω ±10%, 1/2W	500-331	
R527	Resistor, var, comp, linear taper, 500Ω ±20%, 1/4W	580-2001	
R528**	Same as R522		

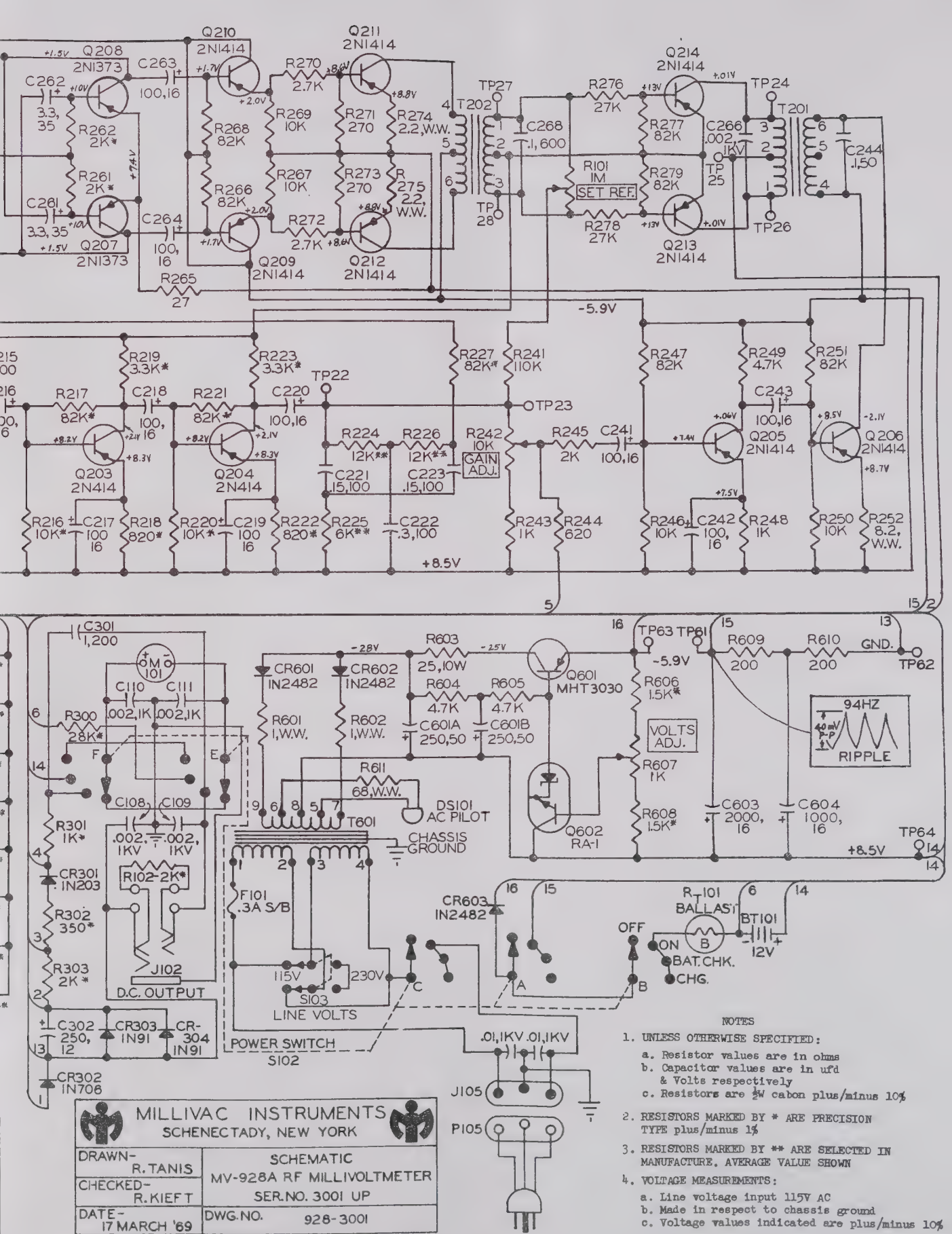
**Selected in manufacture; nominal value listed

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
R529	Resistor, var, comp, linear taper, 1K ±20%, 1/4W	580-2002	
R530**	Resistor, fxd, comp, 1.1K ±10%, 1/2W	500-112	
R531	Same as R501		
R532**	Same as R245		
R533	Same as R511		
R534**	Resistor, fxd, comp, 3.6K ±10%, 1/2W	500-362	
R535	Same as R513		
R536**	Same as R249		
R537 thru R540	Not assigned		
R541	Resistor, var., comp, linear taper, 5M ±20%, 1/4W	580-2008	
R542**	Resistor, fxd, metal film, 5.8M ±1%, 1/2W	519-5804	
R543	Resistor, var, comp, linear taper, 500K ±20%, 1/4W	580-2007	
R544**	Resistor, fxd, metal film, 55K ±1%, 1/4W	512-5502	
R545	Resistor, var, comp, linear taper, 25K ±20%, 1/4W	580-2005	
R546**	Same as R411		
R547	Same as R513		
R548**	Resistor, fxd, metal film, 62.4K ±1%, 1/4W	512-6242	
R549	Same as R545		
R550**	Same as R405		
R551	Same as R511		
R552**	Resistor, fxd, metal film, 69K ±1%, 1/4W	512-6902	
R553	Same as R511		
R554**	Resistor, fxd, metal film, 75K ±1%, 1/4W	512-7502	
R555	Same as R511		
R556**	Same as R554		
R557 thru R600	Not assigned		
R601 & R602	Resistor, fxd, WW, 1Ω ±10%, 2W	510-1R0	
R603	Resistor, fxd, WW, 25Ω ±10%, 10W	560-1002	
R604 & R605	Same as R249		
R606	Resistor, fxd, metal film, 1.5K ±1%, 1/4W	512-1501	
R607	Resistor, var, carbon, linear taper, 1K ±30%, 1/4W	580-1024	
R608	Same as R606		
R609 & R610	Resistor, fxd, comp, 200Ω ±10%, 1/2W	500-201	
R611	Resistor, fxd, WW, 68Ω ±10%, 2W	510-680	
R_T1 thru R_T100	Not assigned		
R_T101	Lamp, Ballast	110-3003	CM239

**Selected in manufacture; nominal value listed
+Used in Model MV-928A only

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
S1 thru S100	Not assigned		
S101	Switch, Rotary, Range	410-1041	
	Switch, Rotary, Range (Comp. Ass'y)	420-1041	
S102	Switch, Rotary, Power (MV-828A)	410-1042	
	Switch, Rotary, Power, Comp. Ass'y. (MV-828A)	420-1042	
	Switch, Rotary, Power (MV-928A)	410-1043	
	Switch, Rotary, Power, Comp. Ass'y. (MV-928A)	420-1043	
S103	Switch, Slide, D.P.D.T.	400-1015	
T1 thru T200	Not assigned		
T201 & T202	Transformer, Interstage	300-2008	
T203 thru T600	Not assigned		
T601	Transformer, Power	300-4010B	
	Miscellaneous		
	Fuseholder	800-2100	Bus HKP
	Knob, bar, w/skirt, Range Switch	800-4128	Buckeye PS-95 BL(L)-52
	Knob, Power Switch	800-4127	Buckeye PS70-PL-2
	Knob, Set Ref	800-4126	Buckeye PS-70D-2
	Plug, Telephone, OUTPUT	800-7800	Switchcraft #60
	Tip, High Impedance	900-2002	
	Optional		
	100:1 Capacitive Voltage Divider	900-2010	
	Adapter, Bridging, Type N "Tee"	900-2020A	
	Termination, BNC, Infinite Impedance	900-2100	


TYPICAL WAVEFORMS
FREQ. 94 HZ.
INPUT
0V
TP24
3V P-P
1mV RF
23V P-P
TP27
75V P-P
COLLECTOR Q207
12V P-P
INPUT
0V
TP22
18mV P-P
1mV R.F.
.8V P-P
CR262 ED90
FREQ. ADJ.
R263
R264 75
CR261 ED90
G201 - D.C. MODULATOR
TP 21
C211 .01, 400
CR201
Q201
R215 3.3K*
R213 82K*
+2.1V
+8.2V
+8.3V
+6.5V
C213 100, 16
Q202 2N414
TP20
R201 20K*
R202 20K*
R203 20K**
R205 20K**
R206 20K*
C207 .002, 1KV
C208 .002, 1KV
C203 .15, 100
C205 .15,100
C201 .01,200
C202 .01,200
R204 10K**
C204 .3,100
C206 .1,100
R207 25*
R 208 1K*
CR202 VR 8.5A
C212 2000, 16
R211 600*
R212 10K*
C214 100 16
R214 820*
GND.
RANGE SELECTOR SWITCH S101
R402 5M*
LO
HI
MID
.001V
.003V
.010V
.030V
.100V
.300V
1V
3V
R403 5M**
R404 250K**
R405 48K**
R406 7.5K**
R407 1.9K**
R408 600**
R409 1.5M*
R410 48K*
R411 35K*
R412 14K*
R413 4K*
R501 5K
R502 2.7K**
R503 5K
R504 2.7K**
R505 5K
R506 2.7K**
R507 5K
R508 2.7K**
R509 5K
R510 2.7K**
R511 20K
R512 3.9K**
R513 50K
R514 5.1K**
R515 50K
R516 5.6K**
R521 350
R522 360**
R523 350
R524 300**
R525 350
R526 330**
R527 500
R528 360**
R529 1K
R530 1.1K**
R531 5K
R532 2K**
R533 20K
R534 3.6K**
R535 50K
R536 4.7K**
R541 5M
R542 5.8M
R543 500K
R544 55K
R545 25K
R546 35K
R547 50K
R548 62.4K
R549 25K
R550 48K
R551 20K
R552 69K
R553 20K
R554 75K
R555 20K
R556 75K
T.C. NETWORK
A101 PROBE CART.
A102 50Ω TERM.
J101
P101 PROBE
C103 .002, 1KV
C104 .002, 1KV
C105 .002, 1KV
C106 .002, 1KV
C107 .002, 1KV
CHASSIS



NOTES

1. UNLESS OTHERWISE SPECIFIED:
   a. Resistor values are in ohms
   b. Capacitor values are in ufd & Volts respectively
   c. Resistors are ½W cabon plus/minus 10%
2. RESISTORS MARKED BY * ARE PRECISION TYPE plus/minus 1%
3. RESISTORS MARKED BY ** ARE SELECTED IN MANUFACTURE. AVERAGE VALUE SHOWN
4. VOLTAGE MEASUREMENTS:
   a. Line voltage input 115V AC
   b. Made in respect to chassis ground
   c. Voltage values indicated are plus/minus 10%

MILLIVAC INSTRUMENTS
SCHENECTADY, NEW YORK

DRAWN- R. TANIS	SCHEMATIC MV-928A RF MILLIVOLTMETER SER.NO. 3001 UP
CHECKED- R. KIEFT	
DATE- 17 MARCH '69	DWG.NO. 928-3001

GUARANTEE

Millivac Instruments, Inc. guarantees each instrument manufactured by us to be free from defects in material and workmanship for a period of one year from date of delivery to the original purchaser. Repairs during this time will be made by us free of charge, but transportation charges both ways will be borne by the customer.

Excluded from this guarantee are tube and transistor replacements, as well as all damages caused by, or related to, abuse of the instrument either electrically or mechanically. In this case, repairs will be billed at cost and an estimate will be submitted for your approval before the work is started.

If an instrument is believed to be defective, please notify our Service Department, giving the model number and serial number of the instrument, as well as describing the nature of the trouble. Our Service Department will then, if necessary, authorize the return of the instrument under the terms of this guarantee and advise how shipment should be made.

CLAIM FOR DAMAGE IN SHIPMENT

If, on receipt, the shipping cartons appear to be crushed or torn, as evidencing rough treatment, a notation should be made on the carrier's delivery receipt indicating this condition.

As each item is opened, it should be inspected to ascertain that no damage has been incurred during shipment. If no damage is visible, operational checks should be performed to make sure that the equipment arrives in its original operating condition. If any damage is revealed, a claim should be filed immediately with the carrier, stating the extent of the damage. A copy of this report should be forwarded to us along with the model and serial number of the instrument. Millivac will then advise how the instrument should be returned for repair or replacement.

SHIPPING INSTRUCTIONS FOR RETURNS TO FACTORY

No instrument should be returned to the factory without prior authorization from Millivac Instruments, Inc. or our authorized representative.

Shipping instructions will be given at the time return of an instrument is authorized. In all cases the instrument should be packed in a strong container and surrounded by sufficient shock-absorbing material.

MILLIVAC
INSTRUMENTS

MANUAL CHANGES

MODEL NO. MV-828A and MV-928A SERIAL NO. 3001 and up

TYPE RF Millivoltmeter

CIRCUIT CORRECTIONS:

1. Change R274 and R275 from 2.2Ω BWH to 15Ω carbon resistors

2. Parallel CR201, 1N816 with another 1N816 in the opposite direction. These will now be CR201A and CR201B.

3. C244 on Schematic should be 1μ F, 50V

Supplement A for: 1-828A-3001
and
1-928A-3001

6-17-69

MILLIVAC
INSTRUMENTS

MANUAL CHANGES

MODEL MV-828A and MV-928A SERIAL NO: 3001 & up

TYPE RF Millivoltmeter

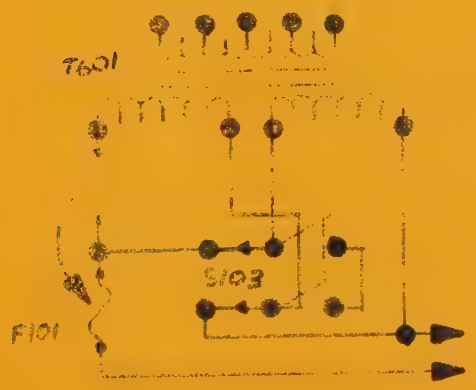
CIRCUIT & PARTS LIST CHANGES

1. R554, 75K 1% replaced by 80K 1%
   Millivac Part No. 512-8002

2. R552, 69K 1% replaced by 75K 1%
   Millivac Part No. 512-7502

SCHEMATIC DIAGRAM CHANGES

1. Correct location of F101 as shown below



Supplement B for: 1-828A-3001 and
1-928A-3001

8-14-69

MILLIVAC
INSTRUMENTS

MANUAL CHANGES

MODEL NO. MV-828A and MV-928A SERIAL NO. 3101 & up

TYPE RF Millivoltmeter

CIRCUIT & PARTS LIST CHANGES

1. Q202 thru Q206, 2N414 replaced by 2N508A
   Millivac Part No. 100-1006

2. R218, R222, 820 Ω 1% replaced by 300 Ω 1%
   Millivac Part No. 512-3000

3. R542, 5.8 meg 1% replaced by 3.6 meg 1%
   Millivac Part No. 520-3604

4. R521, 82K 1/2 wt carbon resistor replaced by 270K 1/2 wt carbon resistor Millivac Part No. 500-274

5. R252, 8.2 Ω BWH replaced by 47 Ω 1/2 wt carbon resistor Millivac Part No. 500-470

6. Parallel R227 with a 15pf 1KV capacitor C226
   Millivac Part No. 610-1032

7. Parallel R224 and R226 with R228; 700K to 1.5 meg 1% resistor (factory adjust)

8. Change R221 from 82K 1% to 110K 1%
   Millivac Part No. 512-1103
   And remove connection at right end of R221 from the junction of R223, R220 and collector of Q204 to the junction of R223 and R219

9. CR302 may be 1N704
   Millivac Part No. 101-2018
   Or G23.8A
   Millivac Part No. 101-2017

Supplement C for: 1-828A-3101 and
1-928A-3101

10-14-69

MILLIVAC
INSTRUMENTS, INC.

MANUAL CHANGES

MODEL NO: MV-828A and MV-928A SERIAL NO: 3101 & up

TYPE RF Millivoltmeter

SCHEMATIC DIAGRAM CHANGES

1. Collector voltage parameters change as follows:

   Q203 from + 2.1V to + 3.7V
   Q204 from + 2.1V to + 4.7V
   Q205 from + .06V to + .35V
   Q206 from - 2.1V to - 5.5V

2. Change output voltage of wave form at TP22 from .8V P-P 1.9V with 1mV R.F. input voltage

Supplement D for: 1-828A-3101 and
1-928A-3101

10-31-69

MANUAL CHANGES

MILLIVAC
INSTRUMENTS

MANUAL CHANGES

MODEL NO. MV-828A and MV-928A SERIAL NO. 3101 and up

shipped after 1 January 1970

TYPE RF Millivoltmeter

CIRCUIT AND PARTS LIST CHANGES :

Q205, Q206, 2N508A replaced by 2N414
Millivac Part No. 100-1004

Supplement F for: 1-828A-3101
and 1-928A-3101

1-1-70

MILLIVAC
INSTRUMENTS, INC.

MANUAL CHANGES

MODEL NO. MV-828A SERIAL NO. 3311 and up and serial no's. listed below

TYPE R.F. Millivoltmeter

3116	3235	3272
3119	3246	3275 thru 3278
3125	3250 thru 3256	3280
3141	3259	3282
3170	3260	3284
3182	3262	3285
3197	3264	3287
3220	3266	3289
3224	3268	3304
3228	3269	3305
3234	3271	3309

MODEL NO. MV-928A SERIAL NO. 3111 and up and serial no. listed below

TYPE R.F. Millivoltmeter

3109

CIRCUIT AND PARTS LIST CHANGES

1. R227, 82K 1%, replaced by 166K 1% (factory adjusted)
2. R228, 1.5 Meg 1% (factory adjusted) replaced by 500K 1% (factory adjusted)
3. R241 - eliminated
4. R101, 1 Meg control, removed from between TP27 and TP28 and installed between TP63 and TP64
5. Add R209, 6.2 Meg, 1/2W Carbon, Millivac Part No. 500-6204 from wiper of R101 to junction of R207 and R208

Supplement G for: 1-828A-3311 & up
1-928A-3111 & up

3-9-70

38980